FRED Reports

Fisheries Habitat Evaluation and Limnological Investigations of Old Franks Lake System, Prince of Wales Island, Alaska 1978-1989

by
T. P. Zadina and M. H. Haddix

Number 112

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation, Enhancement and Development

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Abstract

The Old Franks Lake system was identified in 1978 as a barriered system in need of bioenhancement by the Alaska Department of Fish and Game, FRED Division. An intensive study of the system ensued at this time for habitat evaluation. However, the drainage has multiple private and public land owners which could not agree to terms in the late 70's. The project was shelved until the late 80's when the U.S. Forrest Service began a major program to enhance anadromous fish populations on the Tongass National Forest. In 1989 studies were reinitiated to do a final evaluation and summarize all habitat evaluations from both studies. All land owners and project cooperators came to agreement in 1990. Both fish passes are scheduled for construction in 1992. Limnological studies in 1978 and 1989 indicated the Old Franks Lake system could potentially produce 16,374-17,646 adult sockeye salmon *(Oncorhynchus nerka)*. The available stream and littoral rearing area above the falls could potentially produce 6,189 adult coho salmon *(Oncorhynchus kisutch)*. The remaining available spawning area could potentially produce 350,000 adult chum salmon *(Oncorhynchus keta)* or 236,000 adult pink salmon *(Oncorhynchus gorbushka)* or a combination thereof. Upon returning, these enhanced fish will be harvested in existing commercial and sport fisheries and a potentially new personal use / subsistence fishery.

Introduction

The Old Franks Creek system is a non-anadromous lake system that is currently under pre-construction phase as a viable fishway and bioenhancement site. There are two falls located 0.8 km and 2.4 km upstream from the saltwater confluence that are barriers to anadromous salmonids. Upon completion of these two fishways in 1992 a large drainage will be accessible to anadromous access. The system has three major lakes including: Mary, Old Franks and Upper Old Franks; and two minor lakes named South Lake Mary and Old Franks Lake Number Four. All these lakes are now inaccessible to anadromous fish.

The primary purpose of this study was to establish baseline information for rearing juvenile sockeye salmon and document the in-lake productivity of Mary, Old Franks and Upper Old Franks lakes. Additional goals included establishing baseline information for rearing coho salmon production and spawning habitat for pink salmon and chum salmon. Fisheries investigations defined native fish species present, their abundance, age structure and fitness. The evaluation will be used to identify potential bioenhancement strategies to optimize salmonid production for all species including steelhead trout *(Oncorhynchus mykiss)* in the Old Franks system.

Project Sponsorship --This report represents the results of studies by the Fisheries Rehabilitation, Enhancement and Development (FRED) Division of the Alaska Department of Fish and Game from 1978 to 1989. The report is a requirement of U. S. Forest Service Sikes Act contract number 43-0109-9-0479.

Study Site Description -- The Old Franks Lake system (55°25'43"N, 132°27'53"W) is located approximately 50 km west of Ketchikan in Skowl Arm, Polk Inlet on the East Coast of Prince of Wales Island (Figure 1). All five species of Pacific salmon are present below the lower barrier. Also found are cutthroat trout *(Oncorhynchus clarki spp.)*, steelhead trout and Dolly Varden char *(Salvelinus malma)*. Resident species above the two barriers include cutthroat trout, Dolly Varden char, kokanee *(Oncorhynchus nerka)*, and prickly sculpin *(Cottus asper)*.

The entire system has 307 ha (759 acres) of available rearing and spawning habitat. The creek system is subdivided into areas (Figure 2) and each area is subsequently divided into habitats (Table 1).

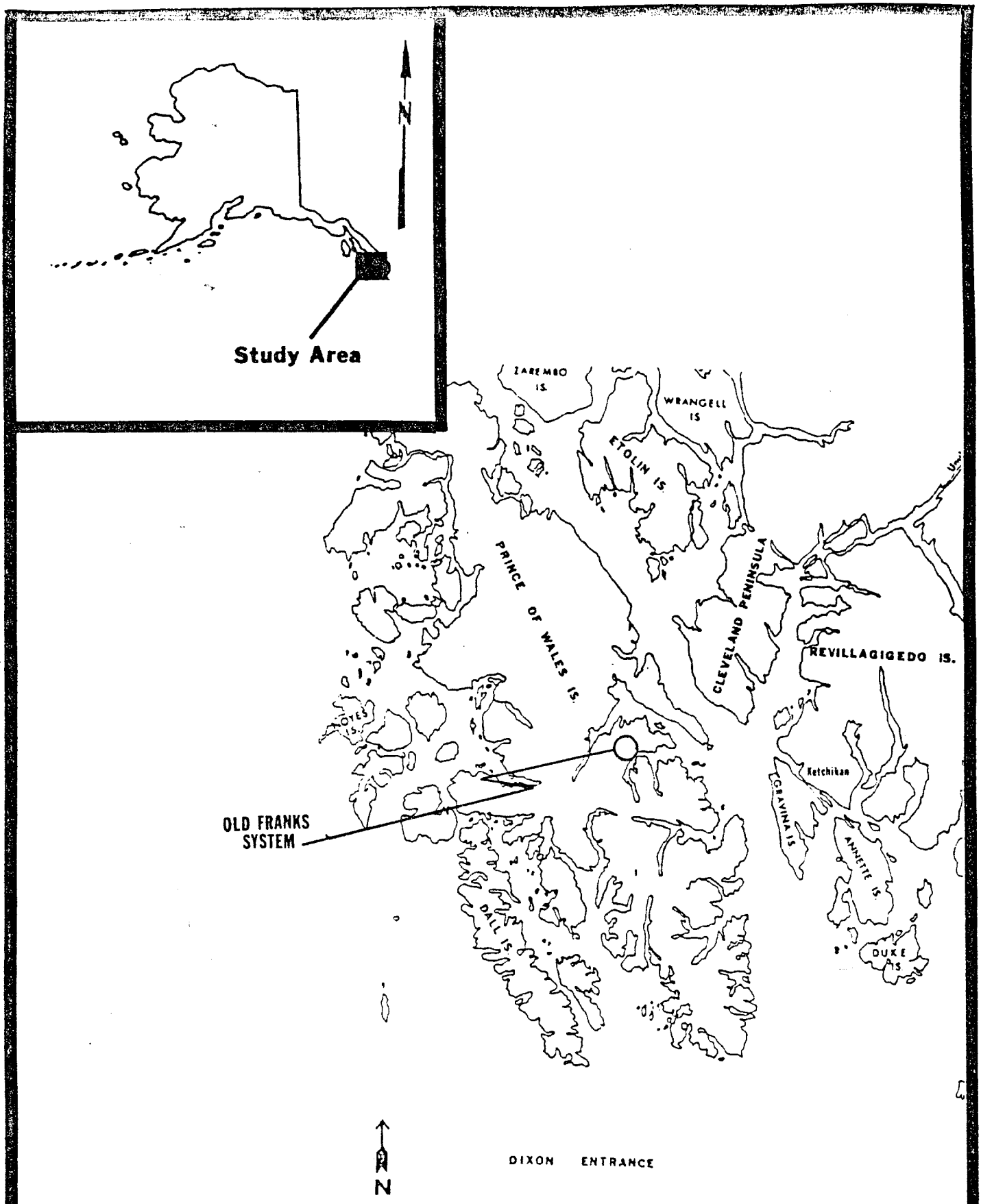


Figure 1. Geographic location of the Old Franks Lake system, Prince of Wales Island, Southeast Alaska.

Old Franks Lake System

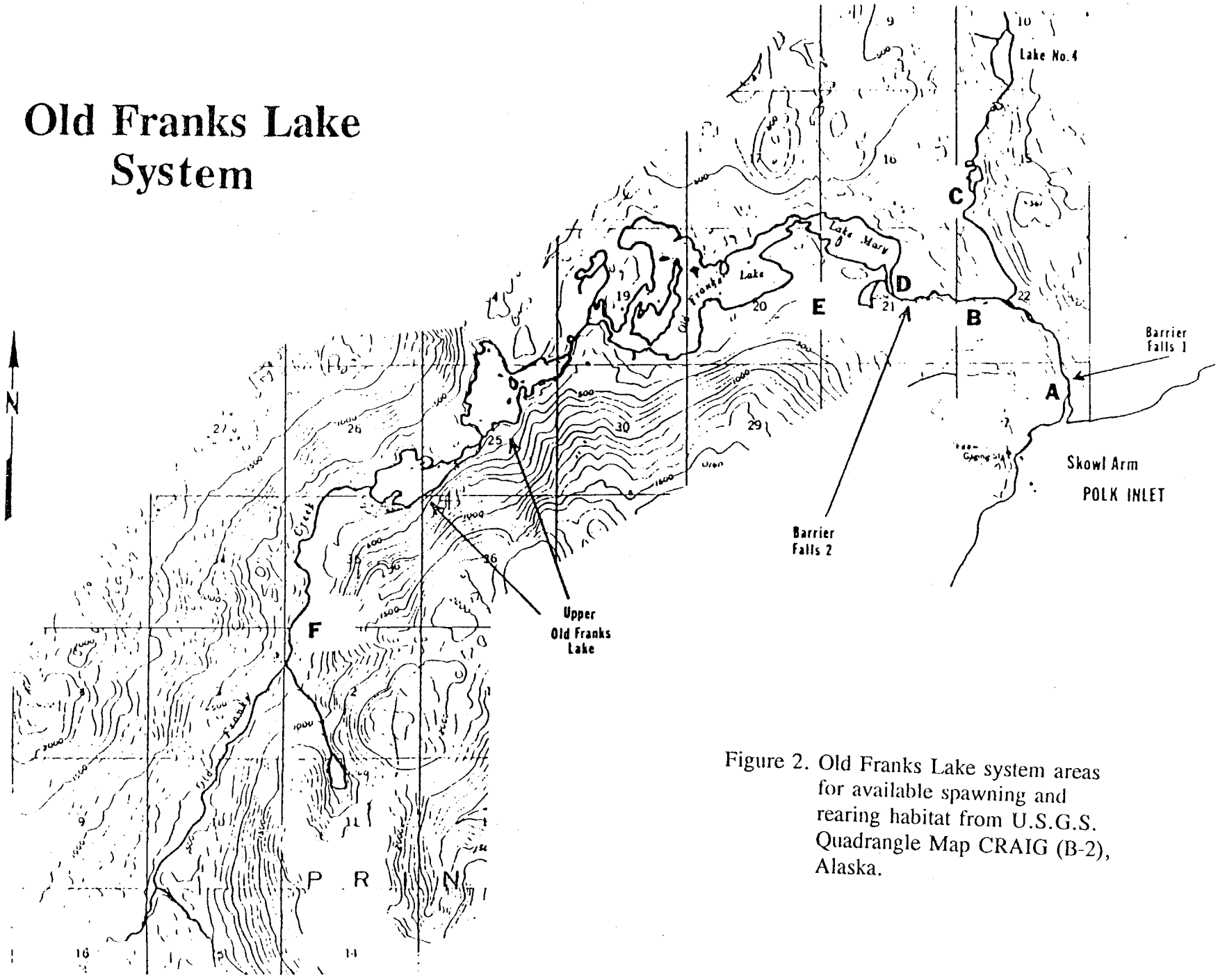


Figure 2. Old Franks Lake system areas for available spawning and rearing habitat from U.S.G.S. Quadrangle Map CRAIG (B-2), Alaska.

Table 1. Available spawning area (ASA) and rearing habitat (ARA) identified by area in the Old Franks Creek system.

Area	Description	Distance (m)	ASA (m^2)	ARA (m^2)
A	Intertidal zone to Falls #1	732	6,208	11,292
B	Falls #1 to Falls #2	792	8,241	13,800
C	North Fork Old Franks Creek	2,390	3,831	25,645
D	Falls #2 to Mary Lake	792	1,741	14,980
E	South Mary Lk to main creek	121	98	511
F	Accessible portion of creek above Upper Old Franks Lake	4,175	40,145	53,974
Totals		9,002	60,264	120,202

Mary Lake, located 2.8 km upstream from tidewater has a surface area of 34.2 ha, with a mean depth of 5.8 m and a volume of 2.11 x $10^6 m^3$ (Table 2, Figure 3).

Old Franks Lake, located 0.1 km upstream from Mary Lake has a surface area of 149.2 ha, with a mean depth of 4.1 m and a volume or 6.94 x $10^6 m^3$ (Table 3, Figure 4).

Upper Old Franks Lake, located 0.4 km upstream of Old Franks Lake has a surface area of 97.1 ha, with a mean depth of 6.4 m and a volume of 5.02 x $10^6 m^3$ (Table 4, Figure 5).

Small Lake South of Mary Lake, located 1.6 km south of Mary Lake has a surface area of 2.75 ha, with a mean depth of 3.5 m and a volume of 0.92 x $10^6 m^3$ (Table 5, Figure 6).

Old Franks Lake Number Four, located 2.4 km above the confluence of Old Franks Creek and 1.6 km below Mary Lake has a surface area of 11.8 ha, with a mean depth of 8.0 m and a volume of 1.03 x $10^6 m^3$ (Table 6, Figure 7).

In addition there are several very small lakes throughout the system. These lakes are considered in the total area of the system but are not mentioned any further in this report.

Table 2. Summary of the physical characteristics and morphometry of Mary Lake.

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of surface area
0	342,000	100.0
5	155,129	45.4
10	70,357	20.6
15	67,315	19.7

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of total volume
0 - 5	1,212,440	57.6
5 - 10	549,930	26.1
10 - 15	344,152	16.3

Lake Surface Area:	34.2 ha (84.5 acres)
Maximum Depth:	17.0 m
Lake Volume:	2.11 x $10^6 m^3$
Shoreline Length:	3,393 m
Lake Elevation:	76.3 m
Mean Depth:	5.8 m
Volume Development:	1.64
Shoreline Development:	1.47

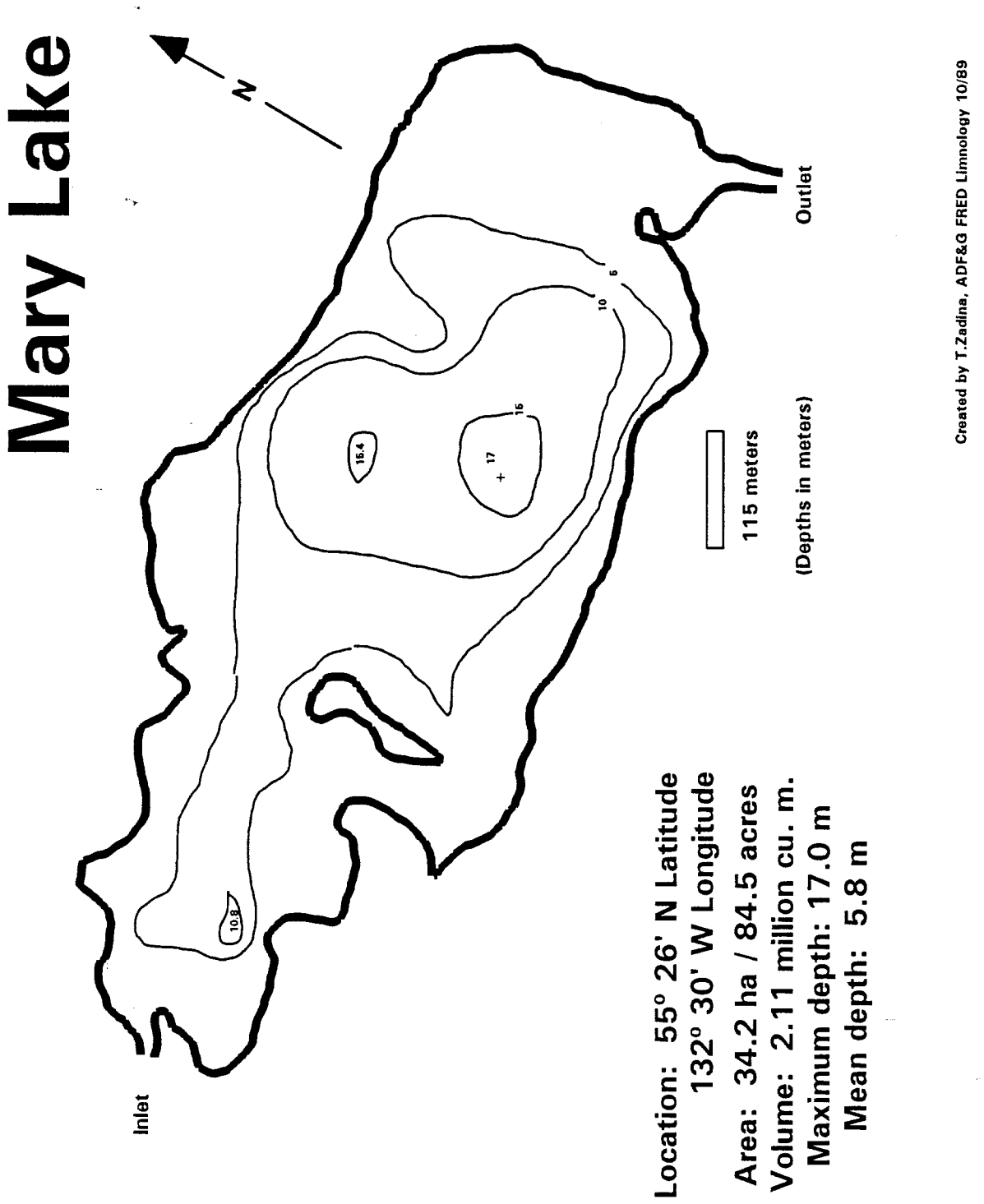


Figure 3. Morphometric map of Mary Lake, Prince of Wales Island, Southeast Alaska.

Table 3. Summary of the physical characteristics and morphometry of Old Franks Lake.

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of surface area
0	1,492,000	100.0
5	402,294	27.0
10	202,184	13.6
15	66,358	4.4
20	35,253	2.4
25	13,479	0.9

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of total volume
0 - 5	4,448,391	64.1
5 - 10	1,482,792	21.4
10 - 15	640,620	9.2
15 - 20	249,963	3.6
20 - 25	177,551	1.7

Lake Surface Area:	149.2 ha (368.7 acres)
Maximum Depth:	27.0 m
Lake Volume:	6.94 x $10^6 m^3$
Shoreline Length:	16,905 m
Lake Elevation:	77.8 m
Mean Depth:	4.1 m
Volume Development:	0.46
Shoreline Development:	3.90

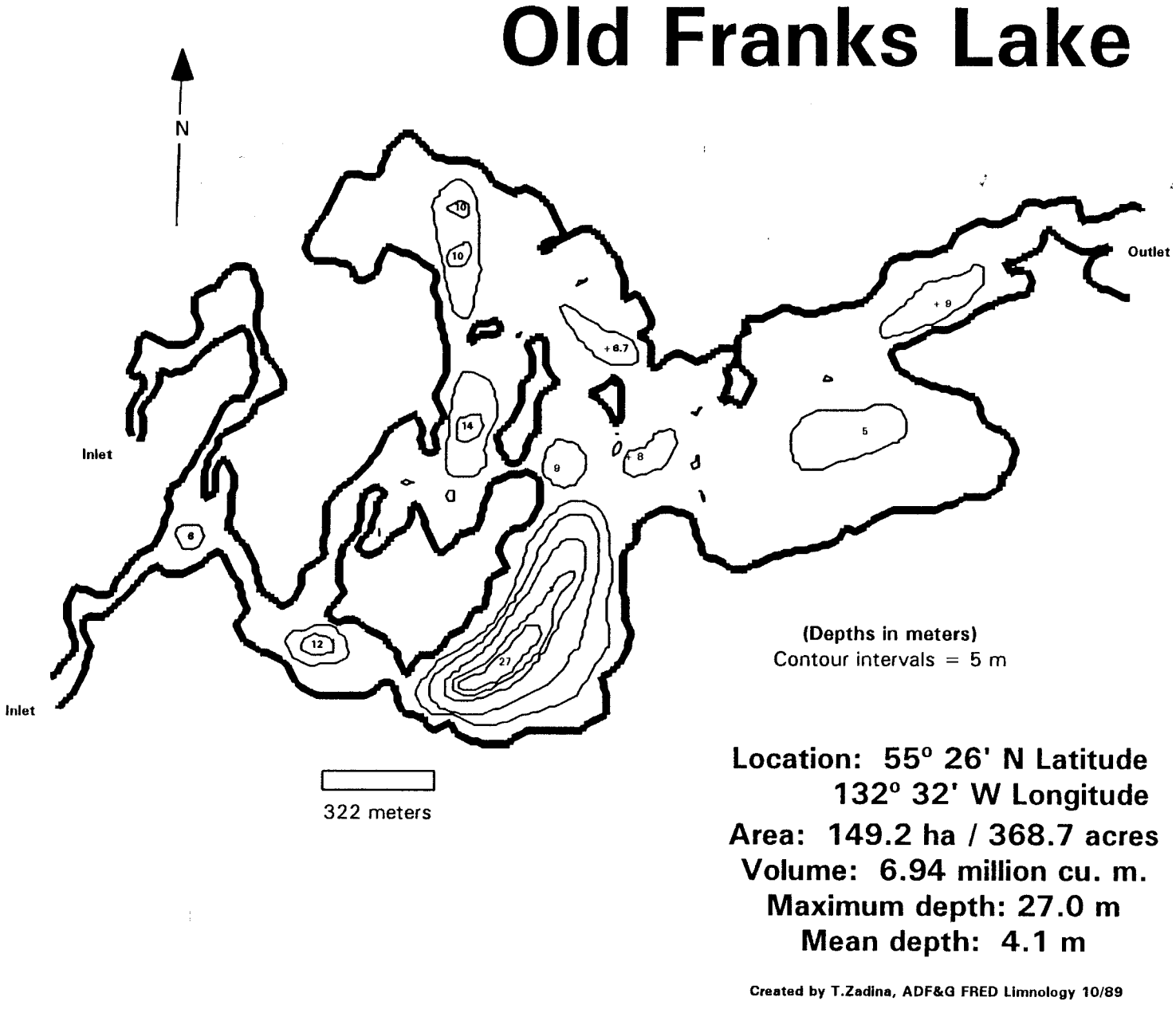


Figure 4. Morphometric map of Old Franks Lake, Prince of Wales Island, Southeast Alaska.

Table 4. Summary of the physical characteristics and morphometry of Upper Old Franks Lake.

Area by Depth Zone

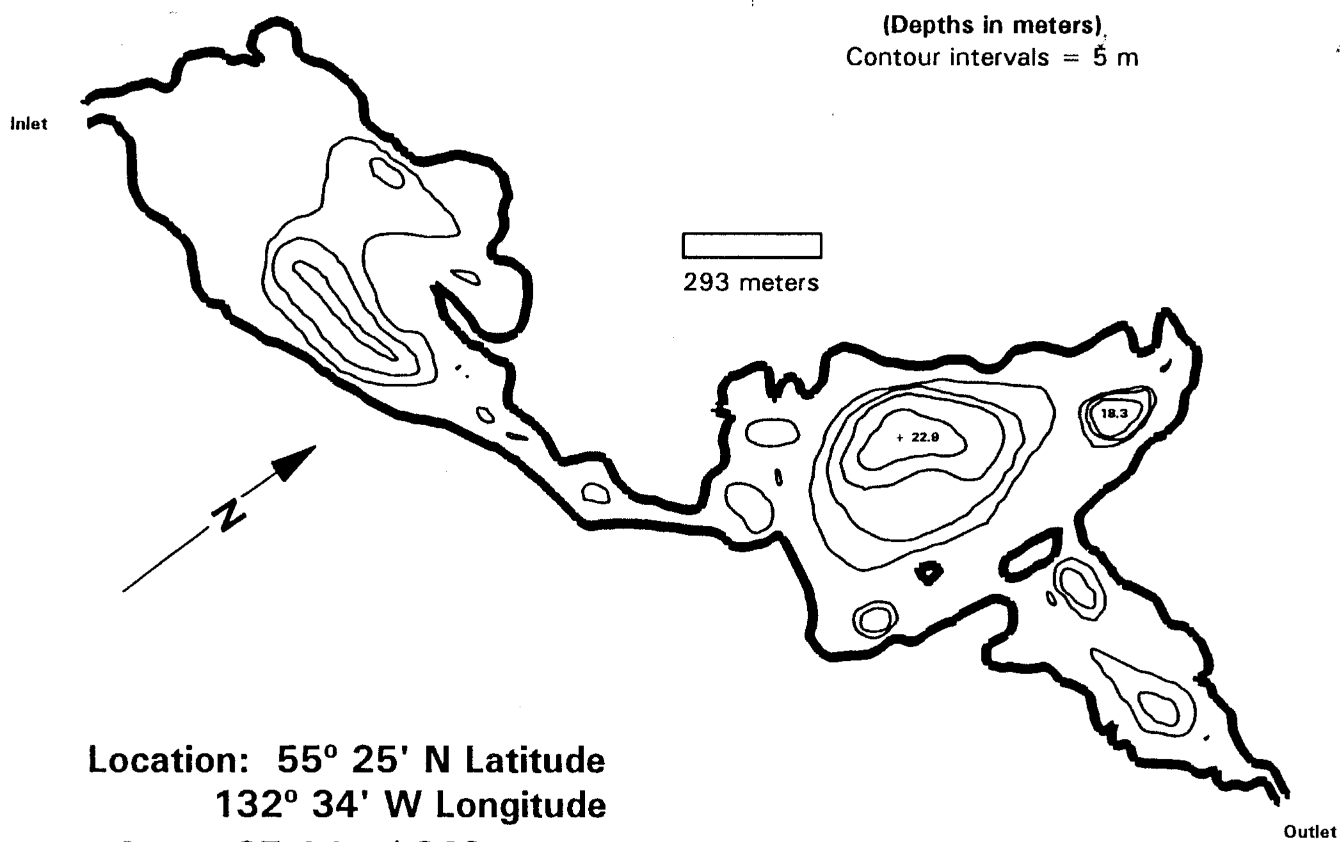
Depth Zone (m)	Area (m^2)	Percent of surface area
0	971,000	100.0
5	316,783	32.6
10	168,264	17.3
15	64,387	6.6
20	18,887	1.9

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of total volume
0 - 5	3,070,661	60.8
5 - 10	1,193,203	23.6
10 - 15	561,229	11.1
15 - 20	196,910	3.9

Lake Surface Area:	97.1 ha (240.0 acres)
Maximum Depth:	22.9 m
Lake Volume:	5.02 x $10^6 m^3$
Shoreline Length:	9,025 m
Lake Elevation:	85.4 m
Mean Depth:	6.4 m
Volume Development:	0.84
Shoreline Development:	2.58

Upper Old Franks Lake



Location: 55° 25' N Latitude
132° 34' W Longitude
Area: 97.1 ha / 240 acres
Volume: 5.02 million cu. m.
Maximum depth: 22.9 m
Mean depth: 6.4 m

Created by T.Zadina, ADF&G FRED Limnology 10/89

Figure 5. Morphometric map of Upper Old Franks Lake, Prince of Wales Island, Southeast Alaska.

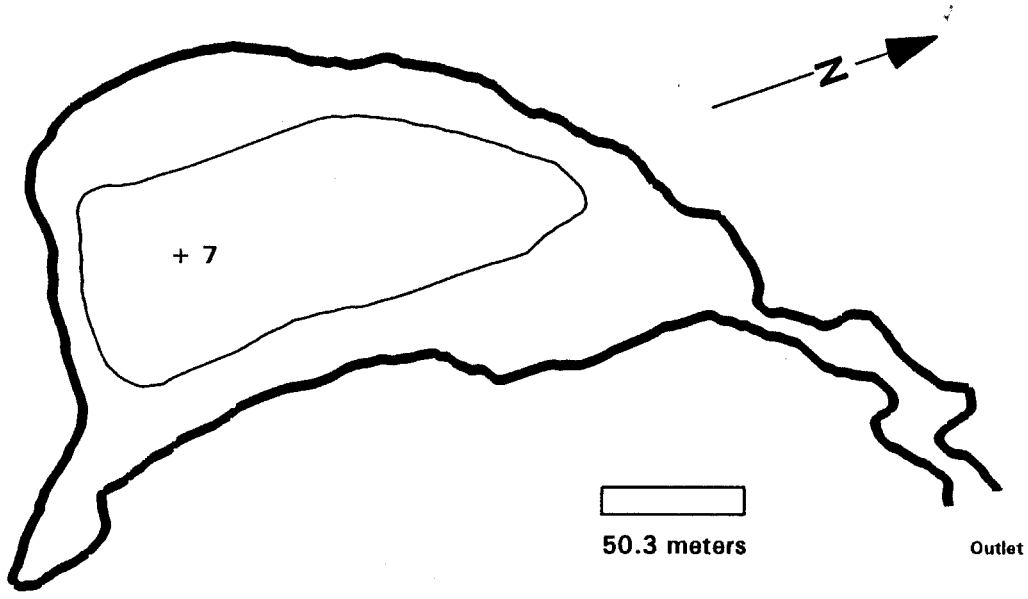
Table 5. Summary of the physical characteristics and morphometry of Small Lake south of Mary Lake

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of surface area
0	27,500	100.0
5	10,500	38.2

Lake Surface Area:	2.75 ha (6.8 acres)
Maximum Depth:	7.0 m
Lake Volume:	0.92 x $10^6 m^3$
Shoreline Length:	775 m
Lake Elevation:	76.5 m
Mean Depth:	3.5 m
Volume Development:	1.50
Shoreline Development:	1.32

Small Lake South of Mary Lake



Contour interval = 5 m
(Depths in meters)

Location: 55° 26' N Latitude
132° 30' W Longitude
Area: 2.75 ha / 6.8 acres
Volume: 0.92 million cu. m.
Maximum depth: 7 m
Mean depth: 3.5 m

Created by T.Zadina, ADF&G FRED Limnology 10/89

Figure 6. Morphometric map of Small Lake South of Mary Lake, Prince of Wales Island, Southeast Alaska.

Table 6. Summary of the physical characteristics and morphometry of Old Franks Lake Number Four.

Area by Depth Zone

Depth Zone (m)	Area (m^2)	Percent of surface area
0	118,000	100.0
5	97,358	82.5
10	63,455	53.8
12.8	10,728	9.1

Volume by Depth Zone

Depth Zone (m)	Volume (m^3)	Percent of total volume
0 - 5	537,569	52.2
5 - 10	399,021	38.7
10 - 12.8	93,589	9.1

Lake Surface Area:	11.8 ha (29.2 acres)
Maximum Depth:	12.8 m
Lake Volume:	1.03 x $10^6 m^3$
Shoreline Length:	1,590 m
Lake Elevation:	85.4 m
Mean Depth:	8.0 m
Volume Development:	1.88
Shoreline Development:	1.31

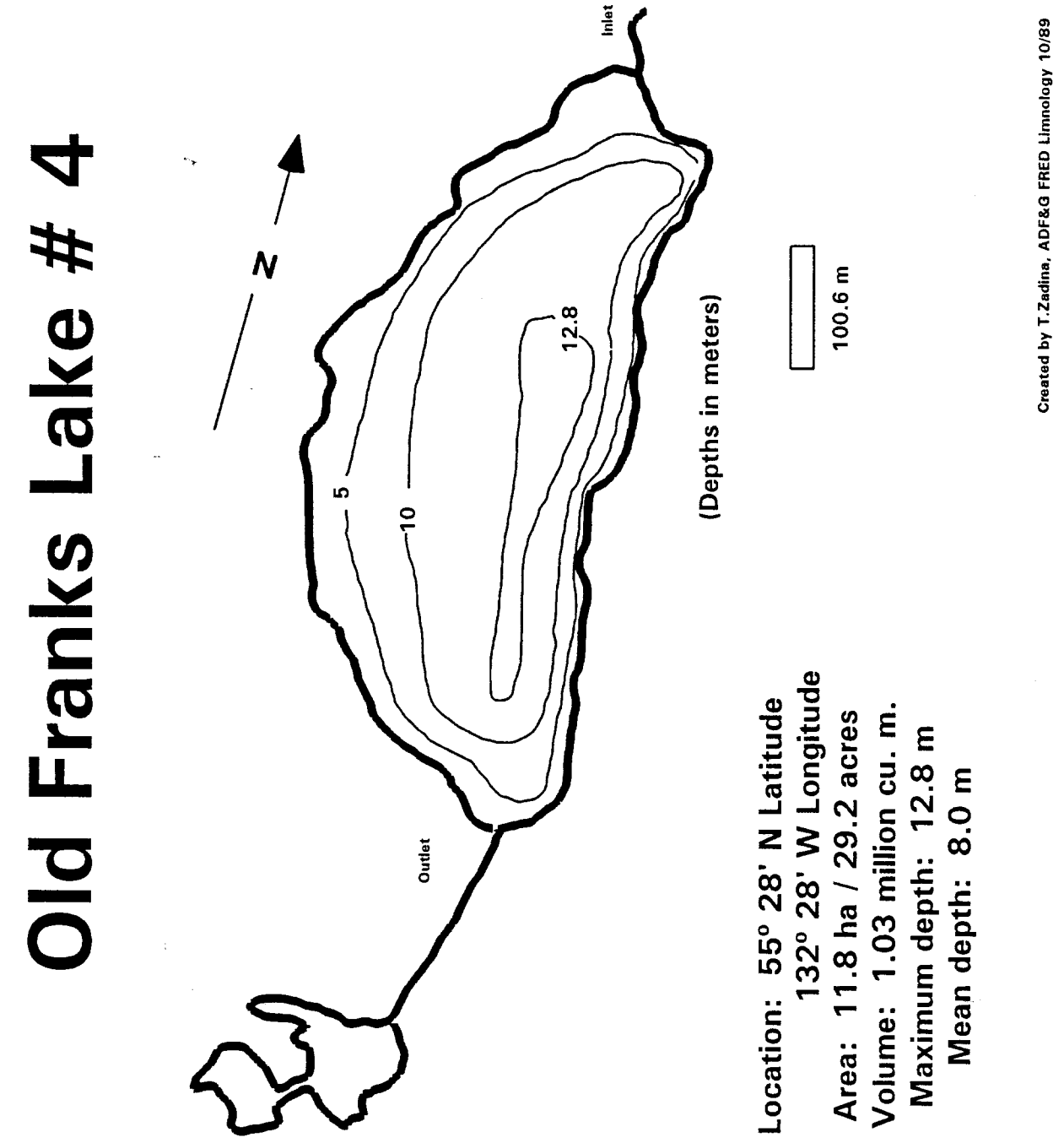


Figure 7. Morphometric map of Old Franks Lake Number Four, Prince of Wales Island, Southeast Alaska.

Methods and Materials

Lake Design

Bathymetric maps were constructed from depth transects taken with a Ross Model T240B fathometer. Depths were recorded on maps of each lake outline. A varying number of transects were taken at each lake to achieve representative sampling of the entire lake.

Limnological Sampling

Sampling to define lake productivity and juvenile sockeye carrying capacity were conducted at Mary, Old Franks and Upper Old Franks in 1978 and July 1989. Limnological samples were collected from two stations at Mary and Old Franks in 1978 and three stations in Upper Old Franks in 1978 and one station located in the deepest area of each lake in 1989. These samples included physical data (e.g., light penetration, temperature profiles and dissolved oxygen levels), water (nutrients and quality) and biological (phytoplankton and zooplankton). In 1978 only physical and biological parameters were compiled after sampling from May through October. The 1978 zooplankton samples were identified and counted by the Institute of Water Resources, University of Alaska, Fairbanks. The 1978 water only and 1989 total sample analysis was accomplished by the ADF&G, FRED Limnology Laboratory in Soldotna, Alaska.

Physical Parameters -- Measurements of light penetration (footcandles) were recorded at 0.5 m intervals from the surface to a depth equivalent to one percent of the subsurface light reading using a Protomatic submarine photometer. The euphotic zone depth (EZD), the depth to which 1% of the subsurface light [photosynthetically available radiation (400-700 nm)] penetrates (Schindler 1971), was calculated as the y-intercept derived by regressing depth against the logarithm (ln) of the percent subsurface light. Euphotic volume (EV) is the product of the euphotic zone depth (EZD) and the lake surface area and represents the volume of water capable of photosynthesis. The photometer was used during the 1989 samples only. Secchi disk (SD) transparency was also used to obtain EZD from average readings using a 20 cm disk. The SD readings were used during the 1978 and 1989

sampling periods. Temperature and dissolved oxygen (DO) levels were taken in 1978 and 1989 at 1 m intervals from the lake surface to the bottom using a YSI model 57 meter. The meter was calibrated using the Winkler method from a 1 m sample. Temperatures were also recorded continuously from May through October 1978 in Mary and Upper Old Franks Lakes using a Ryan Model J180 recording thermograph to the nearest 0.1°C. A daily maximum and minimum were gathered from the recording papers.

Water Quality -- Water samples were collected for quality, nutrient analysis and primary production during 1989. These samples were collected from the epilimnion at the 1 m depth and the mid-hypolimnion from the three main lakes using a Van Dorn sampler. Eight liters of water were collected from each depth, stored in pre-cleaned polyethylene carboys, transported to Ketchikan, and then filtered or preserved for laboratory analysis. Separate subsamples from each carboy were: 1) refrigerated for general tests and metals; 2) frozen for nitrogen and phosphorus analysis; and 3) filtered through a Whatman 4.7 cm GFF glass fiber filter and frozen for analysis of dissolved nutrients (Koenings, et al. 1987).

Phytoplankton -- The primary production analysis displays the algal pigment standing crop of each lake. Samples for the analysis of the algal pigment chlorophyll a (chl a) were prepared by filtering 1-2 ℓ of lake water through a Whatman 4.7 cm GFF glass fiber filter to which 1-2 mℓ of 1N magnesium carbonate were added prior to completion. Filters were stored frozen in individual plexiglas holders until analyzed.

Zooplankton -- Replicate vertical tows were taken at each lake from 1m above the bottom to the surface. The tows were collected using a 0.5 m diameter, 153 μm mesh, 1:3 conical net. The net was retrieved at a constant speed ($\sim$0.5 m$\bullet$sec^{-1}), rinsed prior to removing the organisms, and all specimens were preserved with a solution of 40 g sucrose per liter of 4% neutralized formalin (Koenings, et al. 1987).

Laboratory Analysis

General Water Quality -- Conductivity (temperature compensated to 25°C) was measured using a YSI model 32 conductance meter, and the pH was measured with an Orion 399A ionanalyzer following standard calibrations. Alkalinity was determined by sulfuric acid (0.02N) titration to a pH of 4.5 (APHA 1985). Turbidity, expressed in nephelometric turbidity units (NTU) was determined using a DRT-100 turbidimeter. Water color was determined on a filtered sample by measuring the spectrophotometric absorbance at 400 nm and converting to equivalent platinum cobalt (Pt) units (Koenings, et al. 1987).

Metals -- Calcium and magnesium were determined from separate EDTA (0.01N) titrations after Golterman (1970). Total iron was determined by reduction of ferric iron with hydroxylamine during hydrochloric acid digestion after Strickland and Parsons (1972).

Nutrients -- Filterable reactive phosphorus (orthophosphate) was determined using the molybdenum-blue method as modified by Eisenreich, et al. (1975). Total and total filterable phosphorus utilized the same procedure following acid-persulfate digestion. Total ammonia ($NH_3 + NH^+_4$) was determined using the phenolhypochlorite procedure; and nitrate (NO^-_3) + nitrite (NO^-_2) were determined as nitrite following cadmium reduction and diazotization with sulfanilamide after Stainton, et al. (1977). Total Kjeldahl nitrogen (TKN) was determined as ammonia after sulfuric acid block digestion (Crowther, et al. 1980). Total nitrogen was calculated as the sum of TKN and nitrate + nitrite. Reactive silicon was determined using the ascorbic acid reduction to molybdenum-blue methodology after Stainton, et al. (1977).

Phytoplankton -- Phytoplankton biomass (primary production) was estimated from the algal pigment chlorophyll a (chl a). Chl a was extracted from glass fiber filters after homogenizing the filters in 90% acetone (Koenings, et al. 1987). Chl a concentrations (corrected for inactive phaeophytin) were then determined using the direct fluorometric procedure of Strickland and Parsons (1972) with dilute acid (0.02N HCl) addition after Reimann (1978).

Zooplankton -- *Daphnia* sp. were identified according to Brooks (1957) and copepods were identified after Wilson (1959) and Yeatman (1959). Zooplankton were enumerated from three separate 1 mℓ subsamples taken with a Hensen-Stemple pipet and placed in a 1 mℓ Sedgewick-Rafter counting chamber. Zooplankton body sizes from thirty organisms of each species were measured to the nearest 0.01 mm along a transect in each of the 1 mℓ subsamples using a calibrated ocular micrometer. Zooplankton biomass was estimated using species-specific dry weight vs. zooplankter length regression equations (Koenings, et al. 1987).

Fisheries Assessment

Resident fish -- Fish samples in 1978 were collected using 38 m by 1.8 m variable mesh monofilament gill nets with square mesh sizes of 1.3 cm, 1.9 cm, 2.5 cm, 3.2 cm and 3.8 cm of which both floating and sinking types were used. All fish captured were measured to the nearest millimeter in total length and weighed to the nearest gram on a 500 g Chatillon spring loaded scale. A large percentage of all species captured were also sexed by visceral analysis and aged by otolith and/or scale analysis.

Results

Limnological Assessment

Light Penetration -- In 1978, the mean annual euphotic zone depth (EZD) was 6.55 m for Mary Lake, 6.47 m for Old Franks Lake and 6.51 m for Upper Old Franks Lake (Table 7). The July 1989 sample had an EZD of 8.5 m for Mary Lake, 7.7 m for Old Franks Lake and 7.2 m for Upper Old Franks Lake (Table 8).

Temperature and Dissolved Oxygen Regimes -- Profiles for Mary Lake, Old Franks Lake and Upper Old Franks Lake from 1978 and 1989 are in Tables 9, 10 and 11 respectively. The thermograph records for Mary and Upper Old Franks Lakes for 1978 are presented in Appendix A.

General Water Analysis -- General tests, metals, nutrients and primary production (chl a) from Mary Lake, Old Franks Lake and Upper Old Franks Lake for the 1 m and mid-hypolimnion depths during July 1989 are found in Table 12.

Table 7. Secchi disk readings and EZD extrapolations from Mary Lake, Old Franks Lake and Upper Old Franks Lake for 1978.

Date	Depth (m) In	Depth (m) Out	Depth (m) Mean	1% depth (m)
Mary Lake - Station 2				
May 17	4.8	4.6	4.70	5.68
June 15	4.9	4.6	4.75	5.75
July 18	7.4	7.0	7.20	8.20
Mary Lake - Station 3				
May 17	4.5	4.3	4.40	5.43
June 15	5.5	5.2	5.35	6.34
July 18	7.1	6.7	6.90	7.89
Old Franks Lake - Station 5				
May 16	4.3	4.1	4.20	5.24
June 15	5.1	4.9	5.00	6.03
July 18	6.9	6.6	6.75	7.69
Old Franks Lake - Station 6				
May 16		No Data		
June 15	5.0	4.6	4.80	5.79
July 18	7.8	7.5	7.65	8.60
Upper Old Franks Lake - Station 7				
May 16	4.7	4.5	4.60	5.61
June 14	5.6	5.2	5.40	6.42
July 18	7.1	7.0	7.05	8.01
Upper Old Franks Lake - Station 8				
May 16	4.5	4.4	4.45	5.46
June 14	5.1	4.9	5.00	6.03
July 18	6.7	6.4	6.55	7.52
Upper Old Franks Lake - Station 9				
May 16	5.7	5.5	5.60	6.59
June 14	5.3	5.0	5.15	6.19
July 18	5.9	5.6	5.75	6.73

Overall Yearly Means by Lake	**1% Light**
Mary Lake	6.55
Old Franks Lake	6.47
Upper Old Franks Lake	6.51

Table 8. Light intensity profiles by depth stratum and secchi disk (SD) depths for Mary Lake, Old Franks Lake and Upper Old Franks Lake for July 1989.

Light Intensity (percent)

Depth	Mary Lake	Old Franks Lake	Upper Old Franks Lake
Above surface	$0.18 \cdot 10^4$ (207%)	$0.18 \cdot 10^4$ (209%)	$0.72 \cdot 10^4$ (190%)
5 cm	$0.87 \cdot 10^3$ (100%)	$0.86 \cdot 10^3$ (100%)	$0.38 \cdot 10^4$ (100%)
0.5 m	$0.69 \cdot 10^3$ (79.3)	$0.63 \cdot 10^3$ (73.3)	$0.22 \cdot 10^4$ (57.9)
1.0 m	$0.51 \cdot 10^3$ (58.6)	$0.54 \cdot 10^3$ (62.8)	$0.11 \cdot 10^4$ (28.9)
1.5 m	$0.40 \cdot 10^3$ (46.0)	$0.43 \cdot 10^3$ (50.0)	$0.93 \cdot 10^3$ (24.5)
2.0 m	$0.29 \cdot 10^3$ (33.3)	$0.35 \cdot 10^3$ (40.7)	$0.67 \cdot 10^3$ (17.6)
2.5 m	$0.25 \cdot 10^3$ (28.7)	$0.31 \cdot 10^3$ (36.0)	$0.56 \cdot 10^3$ (14.7)
3.0 m	$0.21 \cdot 10^3$ (24.1)	$0.25 \cdot 10^3$ (29.1)	$0.45 \cdot 10^3$ (11.8)
3.5 m	$0.17 \cdot 10^3$ (19.5)	$0.19 \cdot 10^3$ (22.1)	$0.41 \cdot 10^3$ (10.8)
4.0 m	$0.14 \cdot 10^3$ (16.1)	$0.16 \cdot 10^3$ (18.6)	$0.32 \cdot 10^3$ (8.4)
4.5 m	$0.12 \cdot 10^3$ (13.8)	$0.12 \cdot 10^3$ (14.0)	$0.25 \cdot 10^3$ (6.6)
5.0 m	$0.98 \cdot 10^2$ (11.3)	$0.84 \cdot 10^2$ (9.8)	$0.17 \cdot 10^3$ (4.5)
5.5 m	$0.72 \cdot 10^2$ (8.3)	$0.58 \cdot 10^2$ (6.7)	$0.13 \cdot 10^3$ (3.4)
6.0 m	$0.49 \cdot 10^2$ (5.6)	$0.38 \cdot 10^2$ (4.4)	$0.95 \cdot 10^2$ (2.5)
6.5 m	$0.36 \cdot 10^2$ (4.1)	$0.25 \cdot 10^2$ (2.9)	$0.67 \cdot 10^2$ (1.8)
7.0 m	$0.26 \cdot 10^2$ (3.0)	$0.16 \cdot 10^2$ (1.9)	$0.43 \cdot 10^2$ (1.1)
7.5 m	$0.18 \cdot 10^2$ (2.1)	$0.11 \cdot 10^2$ (1.3)	$0.30 \cdot 10^2$ (0.8)
8.0 m	$0.12 \cdot 10^2$ (1.4)	$0.71 \cdot 10^1$ (0.8)	
8.5 m	$0.85 \cdot 10^1$ (1.0)		
EZD	8.5 m	7.7 m	7.2 m

Secchi Disk (Depths in meters)

	Mary Lake	Old Franks Lake	Upper Old Franks Lake
Down	7.00	6.50	6.75
Up	6.50	6.25	6.25
Mean	6.75	6.37	6.50

Table 9. Dissolved oxygen (DO) and temperature profiles for Mary Lake from July 1978 and July 1989.

	1978		1989	
Depth (m)	D.O. ($mg \bullet \ell^{-1}$)	Temperature (°C)	D.O. ($mg \bullet \ell^{-1}$)	Temperature (°C)
1.0	9.6	17.5	9.0	19.6
2.0	9.7	17.0	9.0	19.5
3.0	9.7	16.8	8.9	19.2
4.0	9.8	16.6	8.9	19.0
5.0	9.4	15.0	8.8	18.2
6.0	9.6	13.0	9.7	13.0
7.0	10.3	10.0	10.6	9.2
8.0	10.4	9.0	10.4	7.2
9.0	10.9	7.9	10.3	6.2
10.0	10.9	6.8	10.2	5.8
11.0	11.0	6.1	10.1	5.3
12.0	11.0	6.0	9.7	5.1
13.0	10.4	5.9	9.4	4.9
14.0	8.0	5.8	8.9	4.8
15.0	3.2	5.3	7.5	4.8
16.0	2.8	5.2	2.2	4.8

Table 10. Dissolved oxygen (DO) and temperature profiles for Old Franks Lake from July 1978 and July 1989.

	1978		1989	
Depth (m)	D.O. ($mg \bullet \ell^{-1}$)	Temperature (°C)	D.O. ($mg \bullet \ell^{-1}$)	Temperature (°C)
1.0	7.6	15.5	9.0	19.6
2.0	7.6	15.5	9.0	19.5
3.0	7.6	15.0	9.0	19.4
4.0	7.5	14.9	8.9	18.8
5.0	7.4	13.2	10.2	15.5
6.0	7.2	11.0	10.8	11.0
7.0	7.4	8.2	10.9	7.4
8.0	7.2	7.4	10.9	6.5
9.0	7.0	6.5	10.9	5.8
10.0	7.2	6.2	10.6	5.4
11.0	7.0	6.0		
12.0	7.0	6.0	10.6	4.8
13.0	6.8	5.9		
14.0	6.6	5.5	10.6	4.4
15.0	6.5	5.3		
16.0			10.3	4.1
18.0			10.3	4.1
20.0			10.2	4.0
25.0			9.2	4.0

Table 11. Dissolved oxygen (DO) and temperature profiles for Upper Old Franks Lake from July 1989.

	1989	
Depth (m)	**D.O. (mg•ℓ^{-1})**	**Temperature (°C)**
1.0	9.0	18.3
2.0	9.1	18.3
3.0	9.1	18.3
4.0	9.0	18.2
5.0	9.0	17.4
6.0	9.8	13.8
7.0	10.4	11.2
8.0	10.5	8.0
9.0	10.7	6.4
10.0	10.5	5.8
11.0	10.4	5.5
12.0	10.2	5.1
13.0	10.3	5.0
14.0	10.1	5.0
15.0	10.0	4.9
16.0	10.0	4.9
17.0	9.7	4.9
18.0	9.4	4.8
19.0	9.1	4.7
20.0	7.4	4.7

Table 12. Summary of General Water Quality parameters including pH, specific conductance, alkalinity, turbidity, color, metal concentrations, nutrient concentrations, and algal pigments within the epilimnion (1m) and mid-hypolimnion of Mary Lake, Old Franks Lake and Upper Old Franks Lake in July 1989.

Lake	Mary		Old Franks		Upper Old Franks	
Parameter / Depth	1 m	Hypolimnion	1 m	Hypolimnion	1 m	Hypolimnion
pH (units)	7.4	6.7	7.4	6.7	7.6	6.7
Conductivity (μmhos•cm^{-1})	40	31	47	33	62	34
Alkalinity (mg•ℓ^{-1})	17.0	12.0	21.0	13.0	22.0	14.0
Turbidity (NTU)	0.6	0.5	0.4	0.4	0.4	0.6
Color (Pt units)	12.1	26.7	9.8	25.6	13.2	29.0
Calcium (mg•ℓ^{-1})	7.4	5.1	8.3	5.1	10.9	6.0
Magnesium (mg•ℓ^{-1})	<0.2	<0.2	1.1	<0.2	<0.2	<0.2
Total iron (μg•ℓ^{-1})	35	55	36	68	73	77
Total-P (μg•ℓ^{-1})	3.1	4.0	3.5	4.1	3.2	3.2
TFP (μg•ℓ^{-1})	2.0	2.3	1.7	2.2	2.2	2.5
FRP (μg•ℓ^{-1})	1.3	1.7	1.4	1.8	1.6	2.0
TKN (μg•ℓ^{-1})	81.1	68.3	63.6	70.7	50.8	62.8
Total N (μg•ℓ^{-1})	87.1	91.6	69.6	91.0	56.8	70.8
Ammonia (μg•ℓ^{-1})	2.5	4.5	3.0	6.2	2.5	4.0
Nitrate + Nitrite (μg•ℓ^{-1})	6.0	23.3	6.0	20.3	6.0	8.0
Reactive silicon (μg•ℓ^{-1})	558	806	682	852	944	872
Chl a (μg•ℓ^{-1})	0.11	0.06	0.19	0.04	0.31	0.03
Phaeo a (μg•ℓ^{-1})	0.07	0.15	0.07	0.14	0.09	0.18

Zooplankton Abundance and Body Size -- Macrozooplankton analysis from samples taken during July 1978 are found in Table 13. Macrozooplankton analysis from samples taken during July 1989 are found in Table 14. This analysis includes species identification, composition and size, macrozooplankton densities and biomass. Old Franks Lake Number Four was also sampled for macrozooplankton during June 1978 (Table 15). The 1978 samples also included some benthic species. These organisms were captured by the net contacting or disturbing the lake bottom during routine sampling. The benthos were identified by species but not enumerated (Table 16).

Table 13. Macrozooplankton densities and composition of samples from July 1978 for Mary Lake, Old Franks Lake and Upper Old Franks Lake.

Species Present	Mary Lake ($\#\cdot m^{-2}$)	Mary Lake (% comp)	Old Franks Lake ($\#\cdot m^{-2}$)	Old Franks Lake (% comp)	Upper Old Franks Lake ($\#\cdot m^{-2}$)	Upper Old Franks Lake (% comp)
Bosmina sp.	3,125	52.6	8,540	46.5	30,620	83.5
Daphnia rosea	125	2.1	555	3.0	230	0.6
Holopedium sp.	805	13.5	90	0.5	0	0.0
Diaptomus sp.	990	16.7	7,145	38.9	0	0.0
Epischura sp.	870	14.6	1,480	8.1	5,105	13.9
Cyclops sp.	30	0.5	555	3.0	695	1.9
Seasonal Mean Macrozooplankton Densities	5,945		18,365		36,650	

Table 14. Macrozooplankton densities, composition, body size and biomass of samples from July 1989 for Mary Lake, Old Franks Lake and Upper Old Franks Lake.

Species Present	Mary Lake (#•m^{-2})	Mary Lake (% comp)	Old Franks Lake (#•m^{-2})	Old Franks Lake (% comp)	Upper Old Franks Lake (#•m^{-2})	Upper Old Franks Lake (% comp)
Bosmina sp.	25,408	40.5	34,811	32.5	23,561	24.2
Daphnia rosea	1,040	1.7	present	<0.1	425	0.4
Daphnia longiremis	present	<0.1	1,868	1.7	0	0.0
Holopedium sp.	10,401	16.6	1,189	1.1	637	0.7
Diaptomus sp.	10,104	16.1	7,302	6.8	0	0.0
Epischura sp.	1,783	2.8	5,094	4.8	12,311	12.7
Cyclops sp.	13,967	22.3	56,716	53.0	60,282	62.0

Species	Mary Lake Body Size (mm)	Old Franks Lake Body Size (mm)	Upper Old Franks Lake Body Size (mm)
Bosmina	0.45	0.46	0.44
Daphnia	0.72	0.83	0.67
Holopedium	0.95	0.83	0.84
Diaptomus	1.14	1.08	
Epischura	1.46	1.27	1.30
Cyclops	0.70	0.60	0.50

Seasonal Mean Macrozooplankton Densities	62,703	106,980	97,216
Seasonal Mean Macrozooplankton Biomass (mg•m^{-2})	263	236	210

Table 15. Macrozooplankton densities and composition of samples from 28 June 1978 for Old Franks Lake Number Four.

Species Present	**(#•m^{-2})**	**(% comp)**
Bosmina sp.	25,210	35.9
Daphnia rosea	210	0.3
Holopedium sp.	10,000	14.2
Diaptomus sp.	415	0.6
Epischura sp.	10,000	14.2
Cyclops sp.	24,375	34.7
Seasonal Mean Macrozooplankton Densities	70,210	100.0

Table 16. Benthic invertebrates identified from samples taken at the Old Franks Lake system during routine zooplankton sampling.

Amphipoda	*Hyalella azteca*
Cladocera	*Sida crystallina*
Copepoda	Harpacticoida (unidentified)
Diptera	Chironomidae (unidentified)
Nematoda	(unidentified)
Oligochaeta	Naididae (unidentified)
Ostracoda	*Cypris* sp.

Resident Fish Studies -- Resident fish were analyzed during the 1978 field season for species composition, size and age distributions. There were 124 cutthroat trout, 76 Dolly Varden char and 9 kokanee analyzed for age, length and weight. The overall mean size data by lake and species are found in Table 17. Length frequency distributions by species and lake are found in Table 18. Age frequency distributions by species and lake are found in Table 19.

Table 17. Overall mean lengths and weights for cutthroat trout, Dolly Varden char and kokanee salmon from the Old Franks Lake system collected in 1978.

Species	Lake	Mean Length (mm)	Mean Weight (g)
Cutthroat	Mary	233.4	156.9
	Old Franks	249.2	217.8
	Upper Old Franks	257.8	198.5
	All Lakes Combined	254.6	197.9
Dolly Varden	Mary	172.6	48.9
	Old Franks	196.9	85.9
	Upper Old Franks	177.0	69.3
	All Lakes Combined	185.2	74.4
Kokanee	Mary	152.5	27.0
	Old Franks	155.0	28.0
	Upper Old Franks	154.5	26.0
	All Lakes Combined	154.1	26.4

Table 18. Length frequency distributions by species and lake from the Old Franks Lake system in 1978.

Species	Length (mm)	Number of Fish by Lake: Mary Lake	Old Franks Lake	Upper Old Frank Lake	Totals
Cutthroat	< 100	0	0	0	0
	101 - 150	2	6	22	30
	151 - 200	3	4	12	19
	201 - 250	2	0	13	15
	251 - 300	0	0	7	7
	301 - 350	2	3	19	24
	351 - 400	0	2	18	20
	401 - 450	1	2	5	9
	Totals	10	18	96	124
Dolly Varden	< 100	0	0	3	3
	101 - 150	3	3	9	15
	151 - 200	4	18	12	34
	201 - 250	1	11	9	21
	251 - 300	0	0	0	0
	301 - 350	0	0	1	1
	351 - 400	0	0	1	1
	401 - 450	0	1	1	2
	Totals	8	33	35	76
Kokanee	100 - 120	0	0	0	0
	121 - 140	0	0	1	1
	141 - 160	2	1	4	7
	161 - 180	0	0	0	0
	181 - 200	0	0	1	1
	Totals	2	1	6	9

Table 19. Age frequency distributions by species and lake from the Old Franks Lake system samples from 1978.

Species	Age	Mary Lake	Old Franks Lake	Upper Old Franks	Total
Cutthroat	1	0	0	0	0
	2	0	0	0	0
	3	3	5	17	24
	4	3	3	10	16
	5	1	2	12	15
	6	1	2	7	10
	7	0	2	8	10
	8	0	2	6	8
	9	1	2	0	3
	10	1	2	3	4
	11	0	0	1	1
	No Age	0	0	32	32
	Totals	10	18	96	124
Dolly Varden	0	0	0	1	1
	1	0	0	2	2
	2	0	0	0	0
	3	1	10	6	17
	4	4	8	8	20
	5	1	11	9	21
	6	2	1	7	10
	7	0	0	0	0
	8	0	0	1	1
	9	0	0	0	0
	10	0	0	1	1
	No Age	0	3	0	3
	Totals	8	33	35	76
Kokanee	No Age	2	1	6	9

Adult Salmonid Studies -- Escapement records are available from 1930 to 1989. These surveys include fish to the lower barrier falls only (Table 20). The surveys were conducted by the U.S. Fish and Wildlife Service prior to 1960 and Commercial Fish Division, Alaska Department of Fish and Game from 1960 to present.

Table 20. Annual escapement by species for Old Franks Creek, 1930 - 1989.

Year	Pink	Chum	Coho	Sockeye
1930	20,000			
1941	20,000			
1948	5,000	10,000		
1960		50		
1961		275		
1962	400			
1963	1,000	4,100		
1964	700	650		
1965	3,500		1,400	
1966	620	1,100		
1968	8,000	3,000		
1969	2,700	300		
1970		809		
1971	250	6,000		
1972		10		
1973	4,745	2,970		
1974		1,600		
1975	7,000			
1976	500	200		
1977	800			
1978	2,120	10	112	
1979	6,800			
1980	3,000	mostly pinks		
1981	1,300	mostly pinks		
1982	1,800	mostly pinks		
1983	6	700		50
1984	22,000	4,500		
1985	22,000			
1986	43,000	1,602	30	7
1987	1,800	400		
1988	4,500			
1989	1,600			

Discussion

Sockeye Salmon Production -- The production of sockeye salmon in the Old Franks Lake system is estimated by using the limnological evaluations from 1989. The lakes carrying capacities are formulated using seasonal zooplankton biomass (kg) in relation to sockeye smolt biomass (Barto and Koenings, 1991). From this modeling formulation an estimate of maximum sockeye smolt production, at a threshold size of 2.2 g, is made. The results are found in Table 21. This can be compared with a euphotic zone model by Koenings and Burkett, 1987 that is based on physical data of existing sockeye salmon nursery lakes within Alaska and the production of sockeye smolts and adults. The production based on this euphotic zone model is found in Table 22. Dependent on the model used, the entire Old Franks system has the potential capacity to produce 147,053 to 150,600 sockeye smolt that would return 16,374 to 17,646 adults using standard 12% marine survival assumptions. The system would need 4,873 to 5,252 female sockeye or 9,746 to 10,504 total adult sockeye to maintain the system at capacity.

Table 21. Sockeye salmon production in the Old Franks Lake System based on a zooplankton biomass model.

Lake	Seasonal Mean Zooplankton Biomass (kg)	Potential 2.2 g Smolt Production	Adult Production
Mary	263	29,672	3,560
Old Franks	236	69,000	8,280
Upper Old Franks	210	48,381	5,806
Totals		147,053	17,646

Table 22. Sockeye salmon production in the Old Franks Lake system based on a euphotic zone volume model by Koenings and Burkett, 1987.

Lake	Surface Area * ($m^2 \bullet 10^6$)	1% Light Level	Euphotic Volume Units	Total Spring Fry (10^6)	Total Smolt	Total Adults
Mary	0.156	8.5	1.33	0.15	30,500	3,315
Old Franks	0.396	7.5	2.97	0.33	68,300	7,425
Upper Old Franks	0.313	7.2	2.25	0.25	51,800	5,634
Totals	0.865		6.55	0.72	150,600	16,374

* Surface area with depth greater than 5 m.

A comparison of the Old Franks Lake system individual lake macrozooplankton biomass to other lakes in Southeast Alaska (Table 23) indicates that the relative production levels are moderately low for a non-sockeye producing system.

Table 23. Comparison of seasonal mean macrozooplankton densities and biomass of Mary Lake, Old Franks Lake and Upper Old Franks Lake to other sockeye salmon nursery lakes (*) and other non-anadromous lakes (#) in southern Southeast Alaska.

Lake	Years Sampled	Macro-zooplankton Density ($\#\bullet m^{-2}$)	Biomass ($mg\bullet m^{-2}$)	Comments
Orchard (#)	89	262,778	821	
Margaret (*)	87 & 89	233,407	643	
Hugh Smith (*)	81 - 84	304,771	548	Fertilized
Heckman (*)	87 - 88	322,530	475	
Hugh Smith (*)	85 - 87	233,570	474	Post-Fertilize
Big (Ratz Hbr)(*)	89 & 91	250,907	465	
Woodpecker (#)	86	59,911	431	
McDonald (*)	82 - 90	108,239	351	Fertilized
Dog Salmon (*)	89	149,855	295	
Mary (O.Frnks)(#)	**89**	**5,945**	**263**	
Bakewell (*)	84, 85, 89	163,690	267	
Old Franks (#)	**89**	**18,365**	**236**	
Klawock (*)	86 - 87	113,262	212	
Patching (#)	87	82,125	212	Pre-stocking
Upper O.Franks(#)	**89**	**36,650**	**210**	
McDonald (*)	81	83,281	186	Pre-fertilize
Badger (*)	85 - 89	80,549	168	Fry stocked
Patching (#)	88	48,536	166	Fry stocked
Salmon (*) Karta R.	84 - 89	56,547	161	
Eagle (#)	89	48,311	150	
Ward (*)	89	156,648	136	
Virginia (*)	86 & 88	40,946	111	Pre-stocking
Virginia (*)	89 - 90	37,950	93	Fry stocked
Neck (#)	87 - 88	23,173	68	

Coho Salmon Production -- There is 108,910 m^2 of available stream rearing area above the first falls and 1,978,946 m^2 of lake rearing are less than 5 m deep (littoral) for a total of 2.088×10^6 m^2 of available rearing habitat for coho salmon. A coho salmon production estimate is based on a fry rearing density of 2,470 per hectare. This total rearing habitat has the capacity to produce a maximum of 51,574 smolt that could produce 6,189 adult coho. The system would need 430 females or 860 adult coho salmon to continue maximum

production above the barrier falls. These production estimates are based on standard ADF&G survival assumptions.

Pink and Chum Salmon Production -- There is a total of 54,056 m^2 of available spawning habitat above the barrier falls. Of this area, about 52,000 m^2 would be available for pink and chum salmon spawning. The spawning area needed per female chum salmon is 1.25 m^2 and per female pink salmon is 0.50 m^2. The available spawning area can hold a maximum of 83,200 adult chum or 208,000 adult pinks or a combination of the two to use the entire spawning habitat above the barriers. Based on standard assumptions for pink salmon (Olsen and McNeil, 1967) and chum salmon (Novak and Denton, 1989) this system could ultimately produce a minimum of 350,000 adult chum salmon or 236,000 adult pink salmon or a combination of the two species dependent on marine survival variations.

Steelhead Trout Production -- Steelhead trout were not included in the production figures. If a steelhead trout program is initiated a pre-smolt stocking format should be used. The steelhead program will eventually lower coho production figures since the two species utilize similar habitat. If a steelhead fry stocking program is used the stocking rate is 247 per hectare. Each hectare used for steelhead has to be traded equally for coho production.

Overall System Production -- With the introduction of all species of pacific salmon above the barrier falls the total production of the system may increase. This increase would come from large numbers of adult carcasses left after spawning. This nutrient addition would not increase the number of fish rearing in the system but may increase the survival rates of the existing fish.

Recommendations

1. A resident fish study to update the 1978 data.

2. Stocking coho salmon from the Karta Lake system stock. In the first year of stocking, 50,000 1.0 g fry and 50,000 pre-smolt should be introduced to the system.

This combination would produce adults starting in year two of the program and continue from this point. Adjustments to stocking numbers should be lowered dependent on the number of adult coho which are enumerated into the system above the barrier falls once the fishpasses are functional. It may not be necessary to do any further stocking dependent on survival rates, holdover fry and returning adults from the first pre-smolt stocking. Evaluation of the program should continue and adjust bioenhancement needs accordingly for coho salmon.

3. Stock pink and chum fry in the upper drainage. Estimated stocking numbers are 3 million chum to fed fry and 4.5 million pink eggs to alevins. The chum salmon program would not start until pathological screening is finished in two years. The first chum fry could be stocked in 1992. The stocking program should continue at this rate for at least three years. This stocking rate would produce a minimum of 45,000 adults per year class. This stocking rate for pink salmon would produce a minimum of 90,000 adults per year class. Stocking at this rate should continue for at least two years. This combination would probably bring the system to its maximum potential. Evaluation of the program should continue and adjust bioenhancement needs for chum and pink salmon.

4. The wild steelhead population currently below the falls may be large enough to populate the upper system on its own. However, if evaluation work finds that the current population is not expanding, remote egg takes from existing stocks could be incubated and reared at Klawock Hatchery and released as pre-smolts or pre-smolt stocking of Karta Lake stocks may be considered.

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Appendix A

Thermograph Record Form (Celcius)

Site: Old Franks System
Location: Mary Lake
Year: 1978

Depth 1m

Thermograph #: 60369
Property #: 11 – 17125
Project: Site Assessment

	May		June		July		August		September		October	
Day	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1			14.2	12.2	15.6	15.4	18.2	17.5	16.7	16.5	10.8	10.5
2			14.0	13.0	15.2	14.8	19.3	17.8	16.5	16.0	10.5	9.8
3			17.2	13.2	15.0	15.0	19.0	18.0	14.8	15.0	9.8	9.5
4	Installed		19.0	13.5	15.0	15.0	19.0	18.2	16.2	15.5	9.5	9.2
5	8.0	7.8	18.2	14.2	16.0	15.0	19.0	18.0	16.3	15.2	9.1	9.1
6	8.0	7.8	17.5	15.0	16.5	15.3	18.0	18.0	15.8	15.2	9.4	9.2
7	8.5	8.0	17.0	15.2	17.2	16.4	18.0	17.5	15.8	15.2	9.3	9.1
8	9.4	8.5	18.0	16.0	17.0	16.5	17.5	17.0	15.8	15.8	9.3	9.3
9	10.0	9.0	17.0	17.0	16.2	16.0	17.6	17.5	15.5	15.5	9.2	9.0
10	10.5	9.0	17.5	16.3	16.0	16.0	17.5	17.5	15.5	15.5	8.9	8.8
11	10.5	9.7	16.8	16.5	18.0	16.0	18.0	17.2	15.2	15.2	8.9	8.7
12	10.7	10.3	18.0	17.0	18.0	16.5	18.1	17.4	15.1	15.0	8.5	8.5
13	12.0	10.5	19.0	17.0	17.2	16.8	18.0	17.5	15.0	14.8	8.5	8.3
14	13.9	11.5	19.0	18.0	16.9	16.2	17.5	17.5	14.8	14.8	8.3	8.2
15	13.2	12.2	18.2	17.5	16.3	16.3	17.5	17.2	14.8	14.2		
16	13.2	12.5	18.4	17.0	16.3	16.0	17.5	17.0	14.2	14.0		
17	13.5	12.0	17.5	16.7	16.4	16.0	18.1	17.0	15.0	14.8		
18	12.0	11.8	16.5	16.0	17.2	16.0	17.5	17.2	14.8	14.2		
19	12.2	11.8	17.0	16.0	18.2	16.5	17.2	17.2	14.7	13.8		
20	12.2	11.8	16.5	16.0	18.0	17.0	18.0	17.2	12.8	12.3		
21	13.1	11.5	16.5	15.7	18.8	17.5	17.8	17.1	12.2	11.8		
22	12.9	12.0	18.5	16.0	19.2	18.2	17.1	17.0	11.8	11.3		
23	14.2	12.0	18.5	16.0	18.5	18.3	17.0	17.0	11.2	11.0		
24	14.2	12.5	18.2	16.8	18.1	17.9	17.0	17.0	11.0	10.8		
25	13.2	12.8	17.0	16.2	17.8	17.5	17.2	17.0	11.1	11.0		
26	13.2	12.8	16.7	16.3	17.5	17.2	17.2	17.0	10.8	10.5		
27	12.5	12.0	16.5	16.0	17.5	17.0	17.3	17.1	10.8	10.5		
28	12.2	11.8	16.7	15.8	17.0	16.8	17.3	17.0	10.9	10.5		
29	12.0	11.5	16.5	16.0	17.1	16.8	17.1	17.0	10.8	10.8		
30	12.0	11.5	16.2	15.5	17.2	17.0	17.1	17.0	11.0	10.7		
31	14.2	11.8			20.0	17.2	17.0	17.0				

Thermograph Record Form (Celcius)

Site: Old Franks System Depth 1m Thermograph #: 60370
Location: Upper Old Franks Lake Property #: 11 – 17126
Year: 1978 Project: Site Assessment

Day	May		June		July		August		September		October	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1			8.0	7.0	12.4	12.0	15.5	15.2	11.5	11.2	9.0	9.0
2			9.0	7.5	12.5	11.8	16.2	15.5	11.5	11.2	9.0	8.5
3			9.0	7.5	12.7	12.4	16.4	16.0	11.5	11.2	8.5	8.5
4	Installed		11.2	8.0	13.2	12.5	16.8	16.0	11.1	11.0	8.5	8.5
5	6.0	4.9	10.7	8.0	13.2	12.5	17.0	16.0	11.0	10.8	9.0	8.5
6	6.5	5.0	10.8	9.5	13.0	12.5	16.2	13.5	11.0	10.8	9.0	8.5
7	6.8	6.2	10.2	9.5	13.3	12.5	13.5	12.0	11.0	10.8	9.0	8.5
8	6.5	6.0	10.3	9.8	13.6	13.2	12.0	12.0	11.5	11.0	8.9	8.5
9	9.1	6.5	10.2	9.7	13.3	12.8	12.0	12.0	10.8	10.8	8.5	8.0
10	9.0	7.0	10.2	9.5	13.5	12.8	12.5	12.0	10.9	10.9	8.0	7.8
11	9.5	8.0	10.0	10.0	14.0	13.0	12.5	12.0	11.2	10.9	7.8	7.5
12	9.2	7.9	10.5	10.0	14.0	13.5	12.5	12.2	11.9	11.0	7.5	7.0
13	10.0	7.4	11.0	10.0	14.0	13.7	13.0	12.5	11.0	10.5	7.3	7.0
14	10.0	7.0	12.0	10.5	14.2	13.5	13.0	12.3	10.8	10.1	7.5	7.4
15	10.2	6.9	11.7	10.7	13.8	13.5	13.0	12.5	10.2	10.0	7.5	7.5
16	9.0	6.5	12.4	11.0	13.5	12.3	12.8	12.2	11.0	9.5	7.5	7.5
17	8.5	6.5	12.5	11.3	12.3	12.0	13.1	12.5	9.5	9.5	7.8	7.5
18	7.1	6.8	12.0	11.5	12.5	12.2	13.5	12.0	9.8	9.3	8.1	7.8
19	6.8	6.3	12.5	11.5	13.0	12.3	12.0	12.0	9.5	8.8		
20	7.5	6.5	12.5	12.0	13.5	12.5	12.0	12.0	8.8	8.8		
21	7.1	6.2	12.3	12.0	14.5	13.0	12.5	12.0	8.8	8.5		
22	9.0	6.5	12.5	12.0	15.4	13.6	12.5	12.1	8.5	8.5		
23	8.0	7.0	14.0	12.0	15.0	14.5	13.0	12.2	8.5	8.5		
24	9.0	7.0	14.0	13.0	15.0	14.5	13.0	12.3	8.7	8.4		
25	9.3	8.0	13.5	12.8	14.5	14.5	12.7	12.2	9.2	8.2		
26	8.5	7.5	13.1	12.5	15.0	14.5	12.5	12.3	9.0	8.2		
27	8.5	6.8	13.0	12.3	14.5	14.0	12.9	12.5	9.0	8.8		
28	6.8	6.3	12.3	12.0	15.1	14.5	14.5	12.1	9.0	8.6		
29	7.0	6.5	12.5	11.8	15.3	14.5	13.0	12.5	9.1	8.8		
30	8.0	6.7	12.3	11.9	15.1	14.8	13.5	13.0	9.0	8.8		
31	7.7	7.2			15.5	14.8	13.5	11.5				